IN SITU PARTIAL MELT ON VENUS: EVIDENCE FOR ANCIENT WATER? V. L. Hansen, Department of Geological Sciences, University of Minnesota Duluth, Duluth, MN 55812, vhansen@d.umn.edu.

Introduction: Mechanism(s) responsible for Venus plains volcanism remain mostly elusive. Distribution of so-called 'shield plains terrain' [1] appears to be globally widespread, and formation of shield terrain might represent a major means of Venus resurfacing, particularly important during an earlier era. Shield terrain comprises countless individual lava flows that emanate from individual closely-spaced eruptive centers; the lavas coalesced to form an ultra-thin, mechanically strong discontinuous 'shield-paint' layer covering tens to hundreds (?) of millions of km^2. Shield-paint lava represents local shallow point-source partial melt across huge expanses of Venus; this unique style of volcanism may provide evidence for ancient Venusian water.

Shield terrain: Small (~1-15 km diameter) volcanic shields occur across much of the surface of Venus, particularly in the lowland plains. The most obvious shields form 100-300 km diameter clusters, called shield fields [2], but Aubele [1] recognized a unit she called shield plains that is much more spatially extensive than shield fields covering millions of km^2. This study, concerned with the formation of shields plains (referred to herein as shield terrain because the descriptor 'plains' holds a range of meanings) rather than shield clusters, results from ongoing geologic mapping across equatorial Niobe, Sologon, and Llorona planitiae, as well as mapping of targeted regions of low-lying ribbon terrain [3]. Mapping employs interactive manipulation of digital NASA Magellan normal and inverted SAR full- and C1-resolution imagery, as well as normal and inverted synthetic stereo images [4] constructed using macros developed by D. A. Young. Both right- and left-look (normal and inverted) full-resolution data were used for detailed mapping.

Shields display a wide range of previously noted characteristics [1,2,5], including dome, cone, and shield shapes, rare flat-topped domes, and more common low-profile forms with little topographic expression. Shields are radar-bright or -dark, with or without a central pit. Shield edifices range from relatively rare 20-km diameter forms to centers at or below SAR resolution. Limits of individual shield deposits can be difficult to define because distal deposits coalesce with adjacent shields. Locally, slight differences in radar backscatter, or limits of structural fabric, defines the boundaries of individual deposits.

Shield deposits coalesce into a relatively coherent layer that forms a volcanic veil with lace-like discontinuity revealing earlier deformed fractured terrain in local regions; lacey holes in the volcanic veil range from 100's of km to SAR resolution. This layer, called shield-paint, posses mechanical strength and can be deformed into wrinkle ridges with regionally coherent patterns. Temporal relations between shield edifices and wrinkle ridges can be difficult to determine given the relatively small size of these primary and secondary structures, however, locally shields are cut by wrinkle ridges, or a wrinkle ridge is diverted around a shield edifice indicating that the edifice formed prior to wrinkle ridge formation; rare shields appear to have emerged or been emplaced on top of existing wrinkle ridges. Between individual wrinkle ridges polygonal microstructure shows an inverse spatial correlation with individual shield edifices; fine-scale polygonal fabric seems to gradually increase away from shield centers, consistent with an interpretation that the shield paint layer is somewhat thicker near edifice/centers, but thins gradually outward. Wrinkle ridges cut across the polygonal fabric boundary with no obvious spatial pattern relative to the polygonal fabric, indicating shield-paint layer coherence across this boundary—although the layer may differ in thickness across the boundary. Map relations indicate that the polygonal fabric formed after shield paint; fabric is best developed where shield paint comprises thin distal deposits.

Extensional fractures that comprise regionally extensive suites are both covered by shield paint and cut the shield paint as a result of local reactivation. Locally shield-filled extensional fractures are inverted into folds or wrinkle ridges due to local contraction following shield layer emplacement. Thus extensional strain locally pre- and post-date shield formation; contractional strain certainly post dates shield formation, although early local contraction cannot be ruled out.

Mechanical coherence of the shield-paint layer is also indicated by the occurrence of a secondary structural fabric marked by delicate, closely spaced, short, parallel lineaments (fractures?) that transect the shield surface in a discontinuous fashion. This fabric occurs in patches with parallel lineament trend and spacing from patch to patch. Fabric continuity across spatially separate regions supports the interpretation that this fabric is secondary and not related to the emplacement of individual shields; the close spacing of lineaments likely reflects deformation of an extremely thin layer—here interpreted as the shield paint layer.

In regions of low lying ribbon terrain shield deposits gently mask and blur older ribbon fabrics, which are continuous in trend from one isolated patch to another;

shield deposits occur at varying topographic levels across ribbon terrain indicating that the layer cannot result from flooding of large volumes of low viscosity lava, but rather emanates from numerous individual centers. Shield-paint locally masks stratigraphically lower ribbon fabrics, and in places the shield-paint layer is in turn dissected by closely spaced parallel fractures; younger shield deposits subsequently variably cover the fractured shield-paint layer.

All of the map relations taken together are inconsistent with the 'global stratigraphy' model [e.g., 6-8]. Full resolution mapping (conducted in many cases in the type location of global stratigraphic units) indicates that ribbon terrain forms the oldest local terrain, but a shield paint layer, locally second formed, can be dissected by fractures forming the so called densely fractured plains unit; this 'unit', which is actually fractured shield paint is in turn locally covered by new shield paint. Thus, the 'densely fractured plains' unit does not consistently pre-date the 'shield plains' unit as indicated in the global stratigraphy model. Furthermore, the shield-paint layer is commonly deformed by wrinkle ridges and polygonal fabric; thus shield terrain simply provides a host for later formed secondary structures, and 'wrinkle ridge plains' cannot be considered a material unit [e.g., 9].

How could the shield-paint layer form? Shield paint cannot represent a typical flood-like lava flow; flood lava, as we know it erupts from relatively singular sources. Shield paint emerges from an almost infinite number of centers, each distinctly separate from one another. Flood lava would be thicker and more continuous than shield paint; it could not extend across vast topographically complex terrain and occur in isolation at varying elevation as shield paint does. Shield paint sources must be small, numerous, localized yet closely spaced, and occur at a range of elevations. If a large magma body had spawned numerous individual shields, tectonomagmatic patterns should reflect thermal stresses associated with the magma body itself, yet delicate, regionally coherent, structures provide no such evidence. If magma traveled from great depth one might expect large volcanic constructs, which are not observed. Rather, shield-paint lava seems to emanate from extensively distributed, small eruptive centers; the close spacing and small size of each magma batch indicates shallow crustal sources. Shield paint may thus represent *in situ* point-source partial melt of Venusian crust with subsequent rise of melt to the surface along, presumably preexisting, fracture conduits.

How could the Venus crust undergo point source partial melt? If we consider basaltic Venus crust, current environmental conditions will not result in formation of shallow partial melt. However, environmental conditions (e.g., ~750K and dry) have probably not always been as they are today. Climate models indicate that during an ancient time of globally thin lithosphere surface T could have exceeded 1000K due to volcanic gases [10], resulting in a relatively steep geotherm. In addition, ancient Venus likely had significantly more water than today, perhaps as much as 16% of a full terrestrial ocean [11]. Under such conditions hydrated mafic crust (hydrous basalt or basalt previously been altered to amphibolite) could undergo shallow *in situ* partial melting triggered by partial melting of hydrous basalt [12] or, perhaps more likely, amphibole dehydration [13-15]. Melt would wick to the surface along fractures where individual 'eruptions' could coalesce into an extensive ultra-thin layer; sustained magma low viscosity might result from the inability of the melt to release heat due to low convective heat loss at high atmospheric pressure, and high surface T. Thus unique global high T could trigger shallow in situ partial melt and cause/allow melt that emerged from numerous individual centers to coalesce into a extensive, discontinuous, yet coherent, ultra-thin surface layer.

This process, which would be triggered by increased global temperature, might favor specific terrain that was predisposed to such reactions either due to mafic composition (e.g., ribbon terrain, likely reworked by the interaction of the crust an deep mantle plumes [3]), and/or crust that could store hydrous phases either as a fluid (in fractures) or as regions predisposed (due to geologic history) to form amphibolite. It is also possible that such reactions could occur at a truly global scale across Venus depending on the phase relations, whose details are unconstrained by available applicable phase experiments. Some regions mapped as 'wrinkle ridge plains' are peppered with shield centers, thus such *in situ* crustal differentiation might have contributed to formation the host material.

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